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Prevalence of Marijuana and Other Substance Use Before and After Washington State's Change from Legal Medical Marijuana to Legal Medical and Non-Medical Marijuana: Cohort Comparisons in a Sample of Adolescents

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Abstract

Background—A growing number of states have new legislation extending prior legalization of medical marijuana by allowing non-medical marijuana use for adults. The potential influence of this change in legislation on adolescent marijuana and other substance use (e.g., spillover or substitution effects) is uncertain. We capitalize on an ongoing study to explore the prevalence of marijuana and other substance use in two cohorts of adolescents who experienced the non-medical marijuana law change in Washington State at different ages.

Method—Participants were 8th graders enrolled in targeted Tacoma, Washington public schools and recruited in two consecutive annual cohorts. The analysis sample was 238 students who completed a baseline survey in the 8th grade and a follow-up survey after the 9th grade. Between

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The authors have no conflicts of interest to disclose.

W. Alex Mason took the lead on formulating the research question and drafting the paper. Charles B. Fleming took the lead on conducting the analyses and contributed to formulation of the research question and the writing. Jay L. Ringle contributed to the analyses and writing. Koren Hanson took the lead on data management, and contributed to the analyses and writing. Kevin P. Haggerty contributed to formulation of the research question and writing.

the two assessments, the second cohort experienced the Washington State non-medical marijuana law change, whereas the first cohort did not. Self-report survey data on lifetime and past month marijuana, cigarette, and alcohol use were collected.

Results—Multivariate multilevel modeling showed that cohort differences in the likelihood of marijuana use were significantly different from those for cigarette and alcohol use at follow-up (adjusting for baseline substance initiation). Marijuana use was higher for the second cohort than the first cohort, but this difference was not statistically significant. Rates of cigarette and alcohol use were slightly lower in the second cohort than in the first cohort.

Conclusions—This exploratory study found that marijuana use was more prevalent among teens shortly after the transition from medical marijuana legalization only to medical and non-medical marijuana legalization, although the difference between cohorts was not statistically significant. The findings also provided some evidence of substitution effects. The analytic technique used here may be useful for examining potential long-term effects of non-medical marijuana laws on adolescent marijuana use and substitution or spillover effects in future studies.

Keywords

marijuana legalization; adolescence; marijuana use; cigarette use; alcohol use

Introduction

Twenty-three states have legalized medical marijuana. In 2012, Colorado and Washington State became the first states to additionally allow non-medical (or recreational) marijuana use for adults aged 21 years and over, and more states are following. It is uncertain what impact emerging non-medical marijuana laws might have on rates of adolescent marijuana use. [1]

A number of studies have examined the potential impact of medical marijuana laws on rates of marijuana use. Cerdá, Wall, Keyes, Galea, and Hasin [2] analyzed data from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) and found higher rates of marijuana use among adults (over age 18) in states with legalized medical marijuana compared to those that prohibited such use. Other studies have reported similar results. [3,4] For example, Wen et al. [4] used data from the National Survey on Drug Use and Health (NSDUH) to examine the effects of medical marijuana laws in seven US states on rates of marijuana use. They reported that medical marijuana laws were associated with increased frequency of marijuana use among adults, aged 21 years and over, by 15–27% as well as youth, aged 12–20 years, by 6–9%. Other studies have provided no evidence of increased marijuana use in the wake of medical marijuana laws, [5,6] particularly when comparisons of states with and without such laws adjust for differences in additional state characteristics. [7,8] Pacula, Powell, Heaton, and Sevigny [9] found that the effects of medical marijuana laws on adult and adolescent marijuana use are contingent on the nature of those laws, such as whether they require registries or licensed dispensaries.

The influence of medical marijuana laws on substances other than marijuana also is uncertain. Wen et al. [4] found evidence for “spillover” of medical marijuana laws on

increased alcohol involvement among adults but not youth. To the extent that use of these substances co-occurs, [10] alcohol use may increase in conjunction with increased marijuana use resulting from medical marijuana laws. Alternatively, a "substitution" effect might operate, [11–13] such that increased marijuana use under legalization could replace the use of other substances. Anderson et al. [11] found that traffic fatalities decreased in 16 US states that had passed medical marijuana laws, and they attributed the decline to reduced alcohol consumption in those states. As with effects of medical marijuana laws on marijuana use, Pacula et al. [9] found that evidence of substitution or spillover effects can depend on the exact nature of those laws.

We take advantage of an opportunity to compare the rates of marijuana and other substance use across two annual cohorts of adolescents, where the cohorts experienced the transition from legal medical marijuana to the legalization of both medical and non-medical marijuana in Washington State at different ages. Washington State voted to legalize medical marijuana in 1998. The law evolved to allow use of home-grown marijuana for medicinal purposes and sale of medical marijuana through dispensaries organized as cooperatives. The number of dispensaries grew dramatically after 2009, when the U.S. Justice Department issued a memorandum advising that federal resources not be used to prosecute medical marijuana patients or dispensaries as long as they complied with state law. In contrast to most other medical marijuana states, [9] Washington has not required individuals who receive authorization for medical marijuana use from a health professional to place their names on a state medical marijuana registry. Prior to the legalization of non-medical marijuana, rates of marijuana use among adolescents in Washington State were relatively high compared to other states. According to 2010 and 2011 NSDUH data, [14] 17% of Washington State youth ages 12 to 17 years reported using marijuana in the past year and 10% reported using marijuana in the past month; the national rates for past year and past month use were 10% and 7%, respectively. [15] In November 2012, Washington State voters approved an initiative to legalize the non-medical use of marijuana for individuals over the age of 21 years. After December 2012, when the possession of less than one ounce of marijuana became legal, the number of arrests for marijuana possession among adults and minors decreased dramatically. [16] The sale of non-medical marijuana through state-licensed retailers began in July 2014, representing the last phase of the new law.

The current analysis is one of the first to explore youth substance use within the new context of non-medical marijuana legalization by capitalizing on an ongoing longitudinal study of two successive cohorts of 8th-grade students recruited from participating middle schools in Tacoma, Washington. During the time frame of the study, the second cohort experienced the Washington State non-medical marijuana law change and the transition to a period of heightened decriminalization, whereas the first cohort did not. Our first objective is to test for cohort differences in the prevalence of marijuana use at follow-up (after 9th grade for both cohorts). We expect that adolescents in the second cohort will report higher prevalence rates of marijuana use (adjusted for baseline substance initiation) compared to those in the first cohort, indicating an increase that might be attributable to the new law. Our second objective is to test for substitution or spillover effects by exploring cohort differences in the likelihood of using marijuana versus cohort differences in the likelihoods of using alcohol and tobacco cigarettes. If spillover effects reflecting higher prevalence rates of other

substance use are observed, then cohort differences in alcohol and cigarette use will be similar to those for marijuana use. If substitution effects reflecting lower prevalence rates of other substance use are observed, then cohort differences in marijuana use will differ significantly from cohort differences in alcohol and cigarette use such that lower rates of alcohol and tobacco use at follow-up will occur in the second cohort compared to the first cohort.

Method

Participants and Procedures

Data are from students enrolled in a randomized controlled trial of the Common Sense Parenting intervention. Students attended one of three middle schools in Tacoma, Washington. At all three schools, the proportion of students in Grades 6 through 8 who were receiving free or reduced-price school lunch was above 70% in the 2010/2011 school year. Potential participants were informed of the project by research staff, who presented the study during core classes and distributed permission slips for the students to take home to their parents. Schools facilitated the recruitment effort in several ways (e.g., by disseminating notices of the study).

Students were enrolled in the project in two cohorts. In the 2010/2011 school year, 122 students were contacted, determined eligible and enrolled in the study. In the second year, recruitment was expanded to two additional schools and 199 were enrolled, 128 of whom attended the same schools from which students were recruited in the first year. To avoid confounding cohort with the addition of two new schools in this cohort comparison analysis, only students from the same original three schools are included here. Of the 250 enrolled in the project from those three schools, 238 (95%) completed a follow-up survey in the summer after their 9th grade year and comprise the analysis sample for the current study. All procedures were reviewed and approved by the University of Washington and Father Flanagan's Boys' Home (Boys Town) Institutional Review Boards as well as the participating school district.

According to student self-report, the racial composition of the analysis sample was 35% Caucasian, 21% African American, 6% Asian American, 3% Pacific Islander, 3% Native American, 8% "Hispanic" as race, and 25% mixed; 17% reported they were Hispanic ethnicity. Moreover, 40% of the students were in households whose income was below $24,000. Of the students in the study, 48% were female, and the mean age of students at enrollment was 13.37 years (SD = 0.51). Cohort comparisons on demographic variables showed no statistically significant differences, except that a higher percentage of students in the second cohort was African American (29% vs. 45%, χ^2 = 6.19, p = .013).

Data Collection and Law Change

Parents and students completed baseline surveys when they enrolled (between November and April for both cohorts) and were asked to complete a post-test survey approximately six months later, in the summer after the 8th grade school year. Students were also interviewed one year after the posttest. The current study uses data from student surveys at baseline and

one year follow-up. Both surveys were completed in families' homes and were self-administered on laptop computers. The student interviews took about 60 minutes to complete and, in addition to questions about substance use, included questions about student experiences in school, family processes, and other behavioral outcomes such as school performance, delinquency, and risky sex. Questions were drawn from a variety of commonly used survey instruments, such as the Alabama Parenting Questionnaire. [17]

Students in the first cohort enrolled in fall 2010 when they entered 8th grade, completing a baseline interview at that time as well as a follow-up interview summer 2012. As noted above, the non-medical marijuana law was approved by Washington State voters in the fall of 2012. Students in the second cohort entered 8th grade and enrolled in fall 2011, completing a baseline interview at that time as well as a follow-up interview summer 2013. The second cohort thus completed its follow-up interview after the law was approved and during a period of heightened decriminalization of marijuana possession, but before full implementation in summer 2014.

Measures

Substance use was measured by self-report of marijuana, cigarette, and alcohol use at both baseline and follow-up. Items were similar to those used in the Monitoring the Future [15] and NSDUH [14] surveys. For the final analysis models, a composite of lifetime initiation of substance use prior to baseline was created indicating whether students reported ever using marijuana, alcohol or tobacco (not initiated was coded 0, initiated was coded 1) in their baseline survey. At follow-up, substance use during the prior 30 days was examined; past-year assessments also were collected but not used here, since the 12-month recall period of those assessments extended back prior to the law change for the second cohort at their follow-up assessment. Given the somewhat low levels of substance involvement within the past month among these early adolescent participants, three separate dichotomous measures of marijuana, alcohol, and tobacco use were created to index use (coded 1) versus non-use (coded 0). Note that information on alcohol use in the prior month at the follow-up time point was missing for 15 participants in the first cohort due to a programming error that was corrected about half way through the follow-up data collection period. To handle missing data on this measure, multiple imputation was used. [18]

Cohort was coded 1 for the first cohort and 2 for the second cohort. Whether the student was African American (coded 1) or not African American (coded 0) was included as a covariate in the final analysis models, because of cohort differences observed on this variable.

Data Analyses

First, prevalence rates for substance use at baseline and follow-up were examined by cohort. Differences between cohorts were assessed initially with chi-square contingency tables. Cohort differences on past month alcohol use at follow-up were assessed with logistic regression models run on 20 imputed data sets; across the imputed data sets, results were averaged and standard errors were computed using Rubin's rules [18]. Multivariate multilevel models (MLM)[19;20] conducted with HLM 6.08 were then estimated to examine differences in substance use by cohort at follow-up, adjusting for substance initiation prior to baseline.

These models were specified to test for both main effects of cohort on substance use and interactions between cohort and type of substance use. The interaction terms test for substitution effects. In these models, indicators for the three types of substance use at follow-up were nested within individual students and variables indexing type of substance use were included in the Level 1 data. The dependent variable in these models is the likelihood to use substance use conditioned on the type of substance use represented by variables in the Level 1 equation. Since the dependent variables were dichotomous, the Level 1 sampling model is Bernoulli and a logistic link function was used. The model that was estimated was:

Level-1 Model

$$\log\left(p_{jk}/1-p_{jk}\right)=\beta_{0k}+\beta_{1k}\left(\text{Type Cigarettes}\right)_{jk}+\beta_{2k}\left(\text{Type Alcohol}\right)_{jk}$$

Level-2 Model

$$\beta_{0k}=\gamma_{00}+\gamma_{01}\left(\text{Initiation prior to baseline}\right)_{k}+\gamma_{02}\left(\text{Cohort}\right)_{k}+\gamma_{03}\left(\text{African American}\right)_{k}+u_{0k}$$
$$\beta_{1k}=\gamma_{10}+\gamma_{11}\left(\text{Initiation prior to baseline}\right)_{k}+\gamma_{12}\left(\text{Cohort}\right)_{k}+\gamma_{13}\left(\text{African American}\right)_{k}+u_{1k}$$
$$\beta_{2k}=\gamma_{20}+\gamma_{21}\left(\text{Initiation prior to baseline}\right)_{k}+\gamma_{22}\left(\text{Cohort}\right)_{k}+\gamma_{23}\left(\text{African American}\right)_{k}+u_{2k}$$

In this model, substance use *j* for individual *k* is predicted by type of substance and individual-level variables. Due to the coding of type of substance use with marijuana as the reference category, γ_{02} represents the effect of cohort on the likelihood of marijuana use at follow-up. The test of a marijuana-for-cigarettes substitution effect is captured by γ_{12} (i.e., the effect of cohort on the difference in likelihoods of cigarette versus marijuana use), while the marijuana-for-alcohol substitution effect is captured by γ_{22} (i.e., the effect of cohort on the difference in likelihoods of alcohol versus marijuana use). Cohort effects are adjusted for substance use initiation at baseline and whether the student was African American. We also ran additional models changing the reference category for type of substance use variables to estimate main effects of cohort on likelihoods of tobacco and alcohol use, adjusting for other model variables. All models were run across 20 imputed data sets, with results combined using Rubin's rules. Experimental condition was not significantly associated with prevalence rates for marijuana, alcohol or tobacco use at either baseline or follow-up. Including an experimental condition index in the MLM analyses did not alter the results reported below. Thus, all students were included in the analysis sample and experimental condition was dropped from the models.

Results

The rates of substance use at pre-test and follow-up are shown by cohort in Table 1. Rates of initiation were similar across cohorts at pretest, both for specific substances and for any substance use. Overall, 13% of the 8th grade students reported ever using marijuana at baseline.

At follow-up, the second cohort (11.8%) reported a higher rate of marijuana use than the first cohort (6.8%), although the difference between cohorts was not statistically significant based on unadjusted contingency table analysis ($p > .05$). The rate of cigarette smoking at follow-up was significantly different across cohorts, with a rate almost three times as high for the first cohort (12.0%) as the second cohort (4.1%), χ^2 (1, N=238) = 4.97, $p = .026$. The rate of alcohol use at follow-up, based on the average rate across 20 data imputations, was also higher for the first cohort (12.4%) than the second cohort (8.3%); however, logistic regression models estimated and averaged across the 20 imputations indicated this difference was not statistically significant ($p > .05$).

Estimates for the HLM model predicting substance use at follow-up are shown in Table 2. The estimated cohort effect on marijuana use was positive, reflecting a higher likelihood of marijuana use for the second cohort adjusting for other variables in the model (Adjusted Odds Ratio (*AOR*) = 2.80, 95% confidence interval (*CI*) = 0.94 – 8.34), but not statistically significant ($p > .05$). The interaction between cohort and the cigarettes variable (coded to index use of cigarettes compared to use of marijuana) was negative and statistically significant, indicating that the difference in likelihoods of cigarette versus marijuana use differed by cohort. This reflects the finding that while members of the second cohort were somewhat more likely to use marijuana, they were less likely to use cigarettes. The interaction between cohort and the alcohol variable (coded to index use of alcohol compared to use of marijuana) was negative and statistically significant, representing the finding that the second cohort was also somewhat less likely to use alcohol.

In a supplemental analysis, changing the reference category for the type of substance use variables indicated that, adjusting for covariates, the second cohort was less likely to use cigarettes compared to the first cohort (*AOR* = .32; 95% *CI* .10 – 1.062.), although this difference was not statistically significant ($p > .05$). Coding so that alcohol was the reference category indicated the second cohort was also less likely to use alcohol (*AOR* = .64; 95% *CI* .23 – 1.83), but this difference was not statistically significant ($p > .05$).

Discussion

This exploratory study of two consecutive annual cohorts of adolescents in Tacoma, Washington found some support for the hypothesis that marijuana use would be more prevalent among teens shortly after the transition from medical marijuana legalization only to medical and non-medical marijuana legalization, although the difference between cohorts was not statistically significant. Cohort differences in the likelihood of marijuana use compared to cohort differences in the likelihoods of cigarette and alcohol use at follow-up were statistically significant and support the hypothesis of a substitution effect, which suggests that youth may replace alcohol and tobacco with marijuana as the latter becomes more readily available. In the current study, whereas the likelihood of marijuana use was slightly higher for the second cohort, the likelihoods of cigarette use and alcohol use in the second cohort were slightly but not significantly lower than in the first cohort.

Some studies have reported increases in marijuana use corresponding to a change in the legal environment for medical marijuana. [3,4] In the current study, marijuana was not made

legal for adolescents and the law had not been fully implemented at the time of the second cohort's follow-up survey (e.g., legal sales began in July of 2014). However, the second cohort may have perceived fewer consequences for possession and use due to the law change immediately after it took effect, resulting in the small increases observed here. Still, alternative explanations of the findings are possible. For example, differences between the two cohorts on unmeasured characteristics might account for the different rates of substance use, the findings might reflect prevailing national trends in substance use, [15] or respondents might have become more honest about their marijuana use after the law change.

Research is mixed regarding the impact of medical marijuana laws on other substance use. [4,9;11] Our data suggest slight decreases in alcohol and cigarette use in the second cohort compared to the first cohort and a change in the relative likelihoods of marijuana use versus other types of substance use after non-medical marijuana legalization in Washington State. Consistent with the notion of a substitution effect, [11–13] individuals prone to using substances may replace alcohol and cigarettes with marijuana as the latter becomes more acceptable and available. Continued monitoring of not only marijuana use trends but also other substance use trends among adolescents is needed as non-medical marijuana legalization takes root. The analytic model used here provides a test of the effect of cohort on the relative likelihoods of different types of substance use and may be a useful strategy for directly examining substitution and spillover hypotheses in future research.

The current study should be viewed as exploratory. Data were collected from a small regional sample of students enrolled in three schools in one school district. Future research will need to draw on larger, representative samples over a longer period of time as marijuana legalization is fully implemented. No corroborating data on adolescents' self-reported substance use were obtained, although there is some evidence that such reports can be valid. [21] Also, no data were collected on electronic cigarette use, and this omission might have impacted the results since such use has been increasing among youth in recent years. [15] Since students came from the same schools, there may be dependencies between students within the same cohorts with respect to substance use that influenced our findings. The study is limited by comparing only two cohorts. Finally, while the non-medical marijuana law change occurred prior to the second cohort completing its follow-up interview, Washington State had a medical marijuana market that had grown dramatically in the three years prior to the law's approval and full implementation of the non-medical marijuana law did not go into effect until after the follow-up data collection for the second cohort. The full effects of non-medical marijuana legalization may not become apparent until retail stores are up and running and prices have stabilized. [9] Still, as more states follow the path paved by Colorado and Washington State, both short-term and long-term studies will be needed to inform policy makers about potential proximal as well as distal influences of the new laws.

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Table 1

Rates of Substance Use at Pre-test (8th Grade) and Follow-up (After 9th Grade) by Cohort

	Pre-test		Follow-up	
	First cohort (*n* = 117)	Second cohort (*n* =121)	First cohort (*n* = 117)	Second cohort (*n*= 121)
	% (*n*)	% (*n*)	% (*n*)	% (*n*)
Marijuana				
Ever used	12.8 (15)	11.6 (14)		
Used in prior 30 days			6.8 (8)	11.8 (14)
Cigarettes				
Ever used	12.0 (14)	9.9 (12)		
Used in prior 30 days			12.0 (14)	4.1 (5)*
Alcohol				
Ever used	19.7 (23)	15.7 (19)		
Used in prior 30 days			12.4[a] (---)	8.3 (10)
Any substance initiation	25.6 (30)	24.0 (29)		

Note.

[a]Percentage based on average across 20 imputed data sets.

*$p < .05$.

Table 2

Estimates for the Multivariate Multilevel Model Predicting Past 30 day Substance Use at Follow-up

	Coeff.	*SE*	*AOR*	*95% CI*
Intercept (γ_{00})	−5.57**	1.03		
Substance Use Initiation at baseline (γ_{01})	2.99**	.55	19.90	6.80–58.19
Second Cohort (γ_{02})	1.03	.55	2.80	0.94–8.34
African American (γ_{03})	−0.10	.54	0.90	0.31–2.62
Type = Tobacco (γ_{10})	3.81**	1.09		
Substance Use Initiation at baseline (γ_{11})	−1.04	.59		
Second Cohort (γ_{12})	−2.16**	.68		
African American (γ_{13})	−0.42	.69		
Type = Alcohol (γ_{20})	3.18*	1.28		
Substance Use Initiation at baseline (γ_{21})	−1.29*	.73		
Second Cohort (γ_{22})	−1.47*	.73		
African American (γ_{23})	0.23	.67		
Random Effect	*Variance*			
Intercept (u_0)	1.50			
Type = tobacco (u_1)	.22			
Type = alcohol (u_2)	.37			

Note. Coeff. = coefficient, *SE* = standard error, *AOR* = adjusted odds ratio, *CI* = confidence interval.

* $p < .05$,

** $p < .01$.